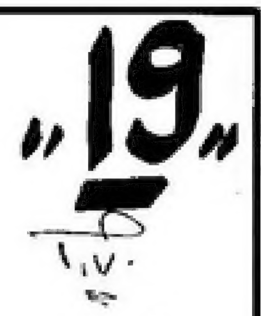


Hydraulics

3rd Year civil

First Term (2009 - 2010)

Chapter ( )

Revision Part (1) final 2004

[illegible] University
Faculty of engineering
[illegible] and water Str. Dept.

Answer the following Questions

Question 1

A-1 i-What is the state of flow when the kinetic flow factor equals 5, 1, and 0.95

ii- what is meant by that the celerity equals the mean flow velocity.

-2 Sketch the hydraulic jump and explain the different zones of state of flow and types of flow which included in this phenomenon.

-3 How dose hump and brink can be used to measure the discharge?

B- A hydraulic jump is formed in a horizontal open channel of rectangular section, the bed width b=5.0 m, the jump height is 11.56 m, and the corresponding Froude number is 6.5 at the initial water depth. Calculate Froude number at the sequent water depth, estimate the jump efficiency, the relative energy loss and estimate the jump length. If a model with scale 1:10 is used to simulate this channel find the discharge, the two conjugate depths, the jump length and the relative energy losses in the model.

Question 2

I- Calculate the mean hydraulic depth and write the dimensions of the most efficient hydraulic section if b=T, plot the shear distribution and isovels. Write three different velocity profile equations used in open channel problems.

II- Sketch the specific force diagram and prove that the minimum specific force occurs at the critical depth.

III- How sudden vertical transition in open channel affect the specific energy for different approaching flow conditions.

IV- A uniform flow of 20 m^3/sec occurs in rectangular open channel of best hydraulic section its bed width equals 5.0 m the channel bed is gradually contracted to 3.0 m find:-

1- The difference in water level just before and at the contraction

2- The contraction width to produce critical depth on it and the drop in water level.

3-draw the relationship between $y_1$and y_2 verses b_2

Question 3

I- Classify the water surface profiles according to the bed slope; give practical examples for each case.

II- Drive the general dynamic equation for gradually varied flow in open channel, and then give three different forms of the dynamic equation.

III- Uniform flow occurs in trapezoidal canal of bed width 1.50 m and side slope 1 (vertical) 2 (horizontal) and bed slope 0.002. The flow depth is 1.80 m. is this flow sub-critical or supercritical.

Question 4

I- If the head loss through bridge peir in rectangular channel is function of (bed width B, peir width b, upstream water depth y_1, water depth through the vent y_2, downstream water depth y_3, the discharge passing Q, density ρ, viscosity μ, and gravity acceleration g). If the head loss = $(y_1 - y_3)$ find the dimensionless parameters for this problem.

II Show how the V-notch can be calibrated to measure the discharge

III- Test on 60^{o} V-notch weir yield the following values of head H on the weir and discharge (Q)

H (cm)	10.51	13.90	19.35	19.93	20.27
Q (l/sec)	3.03	5.8	13.03	13.03	14.72

By means of list squares method, determine the constants in $Q = CH^{m}$ for this weir. What is the percentage error at H=19.35 cm.

Question 5

A- Sketch the vertical pressure distribution in open channel section if the bed is convex once and another time is concave.

B- A pressure pipeline of 3.0 km length is to be constructed to convey irrigation water against a static head of 31.0 meters. The minimum required discharge is 280 m^3/hour, while the maximum required discharge is 320 m^3/hour, the sum of minor losses is $5\frac{v^2}{2g}$. Three pumps are available and the characteristic of each pump is tabulated below.

Q (m^3/hour)	0	40	80	120	160	200	240	280	[illegible]
H (m)	60.0	58.0	55.0	50	45	38	27	17	[illegible]
η %	0	40	70	88	92	78	65	50	[illegible]
N.P.S.H (m)		3	3.2	3.5	4	4.2	4.7	5.2	5.5

Two pipeline are available; the diameter of the first pipe is 0.3 m while the diameter of the second pipe is 0.4 m, the pipe friction factor have a constant value F= 0.02 for both pipe sizes (take h_{fs} = 1.5 Q^2).

Required

1- which pipe size is to be constructed to convey the minimum and maximum discharge?

2- Determine the minimum number of pumps to be used to convey minimum discharge. Estimate the power required to running each pump.

3- Determine the minimum number of pumps to be used to convey maximum discharge. Find the power lost at the control valve.

4- Find the maximum pump height above the water level in the above two cases.

Examiners

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Final 2004

Q(1): (A)

1- (i)

$\lambda = 5$, $\lambda = 1$, $\lambda = 0.95$

$\lambda = F^2$

- $F^2 = 5 \Rightarrow F = 2.24$

$F > 1$ (super critical)

- $F^2 = 1 \Rightarrow F = 1$

(critical flow)

- $F^2 = 0.95 \Rightarrow F = 0.97 < 1$

(sub critical flow)

(ii)

$C = \sqrt{g \cdot y}$

$V = \sqrt{g \cdot y}$

$\frac{V}{\sqrt{g \cdot y}} = 1 = F$

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2-

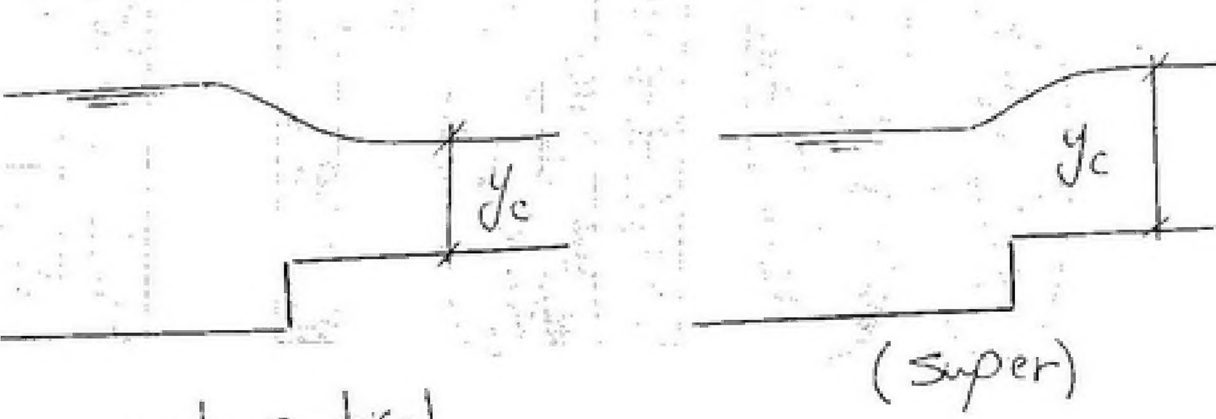
① super critical $F > 1$

② Transitional

③ sub critical $F < 1$

3-

hump:



(super)

sub-critical

$$y_c = \sqrt[3]{\frac{q^2}{g}} \Rightarrow q = \text{—}$$

$$Q = q \times B \quad \text{(Rectangular)}$$

$\because \frac{Q^2}{g} = \frac{A^3}{T}$ at $y = y_c$

$\Rightarrow Q = \checkmark$ (non Rectangular)

Brink:

y_{brink}

$y_{brink} = 0.715\, y_c$

$\Rightarrow y_c = \checkmark$

$y_c = \sqrt[3]{\frac{q^2}{g}} \Rightarrow q$

$Q = q \times B$

(B):

- $H_J = 11.56$ m
- $F_1 = 6.5$

$B = 5.0$ m

Req. - $F_2 = ?$, $\eta = ?$, $\frac{h_L}{E_1} = ?$

- L_J

<u>sol.:</u>

$$\because \quad H_J = y_2 - y_1$$

$$11.56 = y_2 - y_1 \longrightarrow (1)$$

$$\because \quad \frac{y_2}{y_1} = 0.5\left[\sqrt{1 + 8F_1^2} - 1\right]$$

$$\therefore \quad \frac{y_2}{y_1} = 0.5\left[\sqrt{1 + 8 \times 6.5^2} - 1\right]$$

$$y_2 = 8.7\, y_1 \longrightarrow (2)$$

from (2) in (1)

$$11.56 = 8.7 y_1 - y_1 = 7.7 y_1$$

$$\therefore \quad y_1 = 1.50 \text{ m}$$

$$y_2 = 13.10 \text{ m}$$

$$\because \quad \frac{y_1}{y_2} = 0.5\left[\sqrt{1 + 8F_2^2} - 1\right]$$

$$\frac{1.5}{13.1} = 0.5\left[\sqrt{1 + 8 \times F_2^2} - 1\right]$$

$$F_2 = 0.25 \quad \#$$

$$\eta = \frac{E_2}{E_1}$$

$\because \quad F_1 = \dfrac{V_1}{\sqrt{g \cdot y_1}}$

$$6.5 = \frac{V_1}{\sqrt{9.81 \times 1.5}}$$

$$\therefore \quad V_1 = 24.9 \quad m/s$$

$\because \quad F_2 = \dfrac{V_2}{\sqrt{g \cdot y_2}}$

$$0.25 = \frac{V_2}{\sqrt{9.81 \times 13.1}}$$

$$V_2 = 2.8 \quad m/s$$

$$\therefore \quad E_1 = 1.5 + \frac{(24.9)^2}{2 \times 9.81} = 33.0 \ m$$

$$E_2 = 13.1 + \frac{(2.8)^2}{2 \times 9.81} = 13.50 m$$

$$\frac{h_L}{E_1} = \frac{E_1 - E_2}{E_1} = \frac{33 - 13.5}{33}$$

$$= 0.60 \quad \#$$

$$\eta = \frac{E_2}{E_1} \times 100 = \frac{13.5}{33} \times 100$$

$$= 40.9\%$$

$$\therefore \quad L_J = 5.2 y_2 = 5.2 \times 13.1 = 68.12 m \quad \#$$

- $L_r = \frac{1}{10}$

- $Q_m = ?$, $(y_1)_m$, $(y_2)_m$, $(L_J)_m$,

$(h_L/E_1)_m = ?$

$Q_p = A_1 \times V_1$

$= (5 \times 1.5) \times 24.9 = 186.80\ m^3/s$

$\because Q_r = \frac{Q_m}{Q_p} = \frac{L_r^3}{T_r} = \frac{L_r^3}{L_r^{1/2}} = L_r^{2.5}$

$\left(\frac{1}{10}\right)^{2.5} = \frac{Q_m}{186.8}$

$Q_m = 0.60\ m^3/s$ #

$\because (y_1)_r = \frac{(y_1)_m}{(y_1)_p} = L_r$

$\frac{1}{10} = \frac{(y_1)_m}{1.5} \Rightarrow (y_1)_m = 0.15\ m$ #

$\because (y_2)_r = \frac{(y_2)_m}{(y_2)_p} = L_r$

$\left(\frac{1}{10}\right) = \frac{(y_2)_m}{13.1} \Rightarrow (y_2)_m = 1.31 m$ #

$\because (L_J)_r = \frac{(L_J)_m}{(L_J)_p} = L_r$

$\frac{1}{10} = \frac{(L_J)_m}{68.12} \Rightarrow (L_J)_m = 6.81 m$ #

$\because (h_L/E_1)_r = \frac{(h_L/E_1)_m}{(h_L/E_1)_p}$

$\frac{h_L}{E_1} = \frac{L_r}{L_r} = 1$

$(h_L/E_1)_m = (h_L/E_1)_p$

$= 0.60$ #

Q(2): I

$y_h = ?$, dim. B.H.S

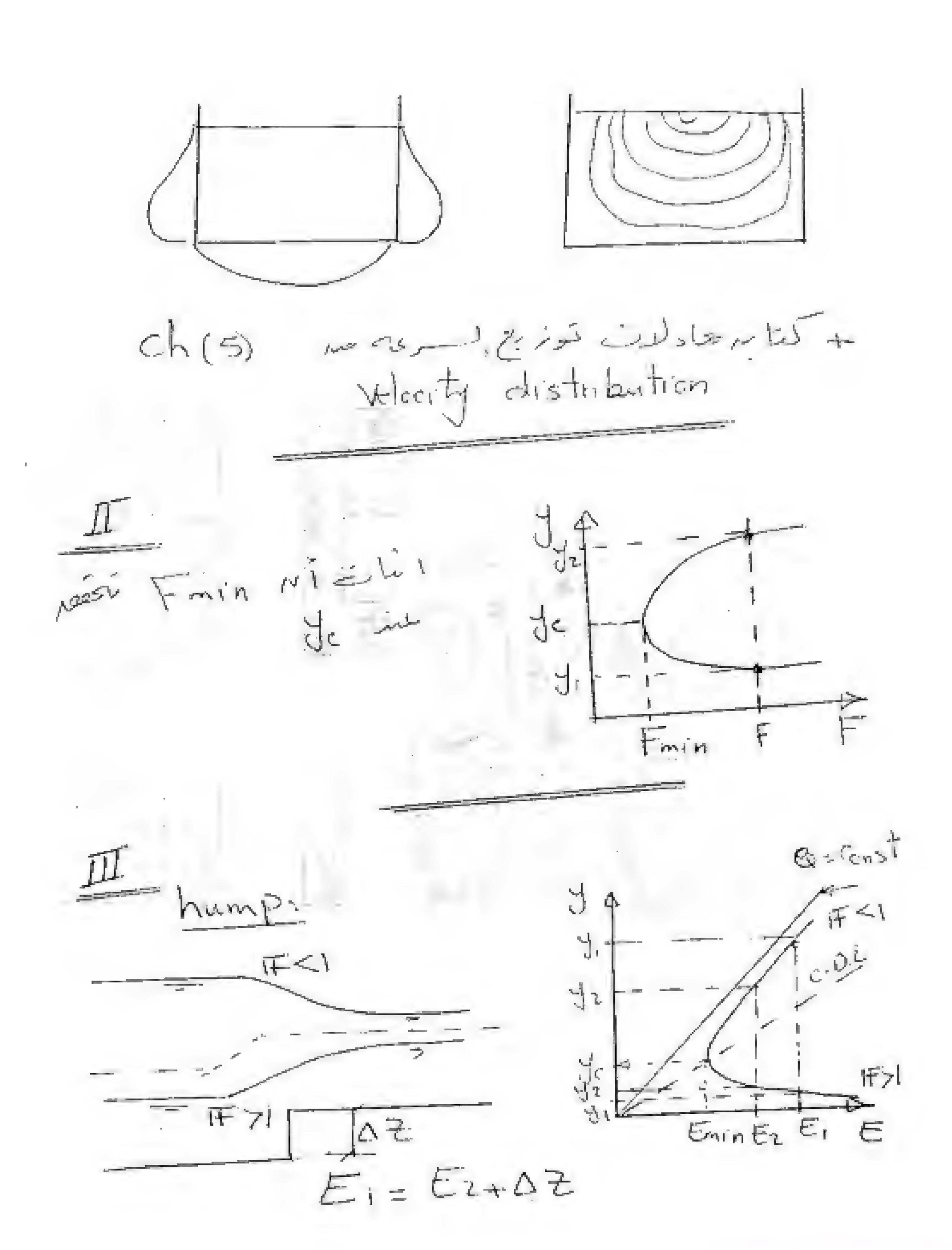
T, y, B

$y_h = \frac{y \times B}{B}$

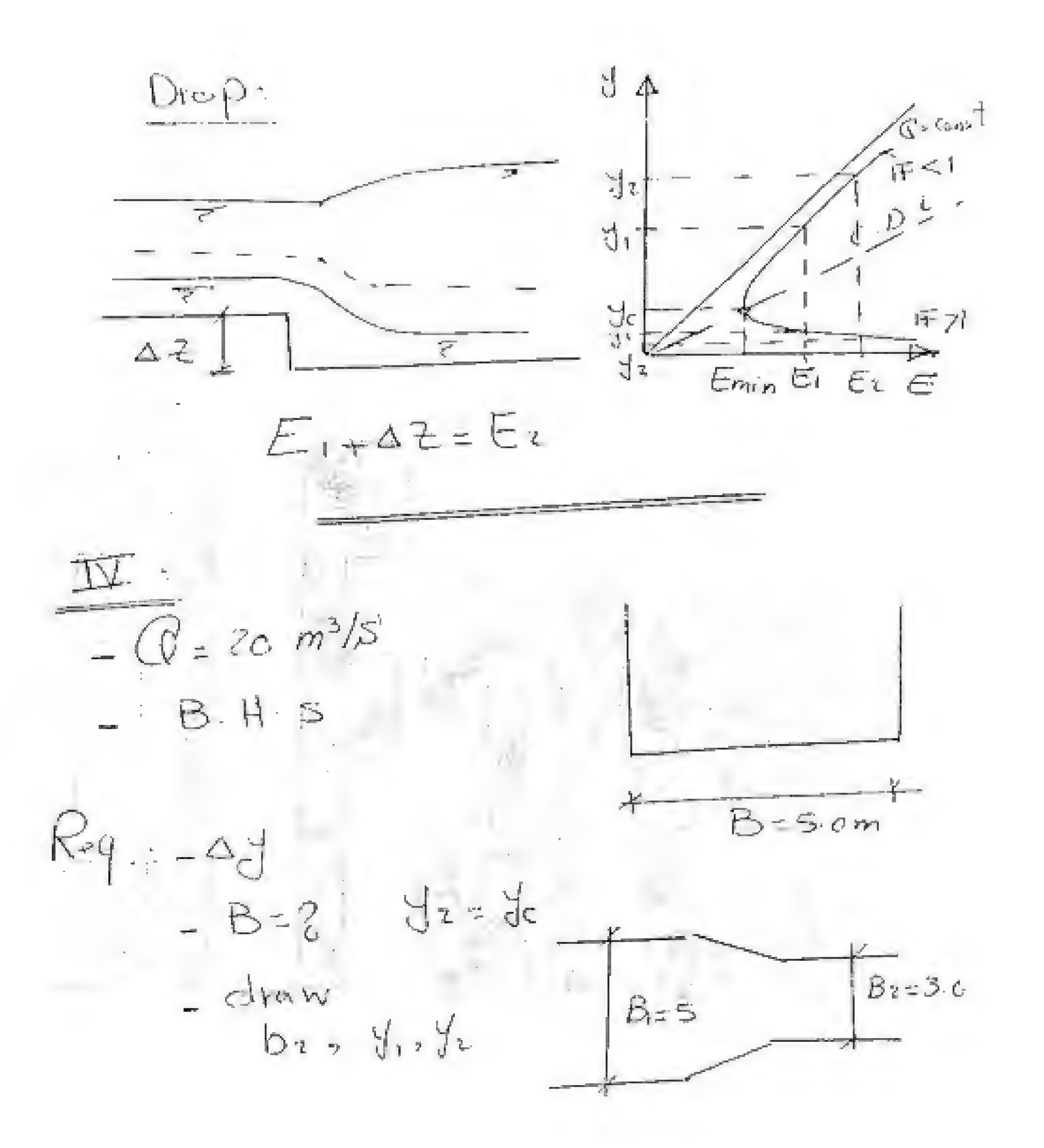
$y_h = y$ #

For B.H.S

$B = 2y$ #



Ch (5)
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Velocity distribution
II
y
y_2
y_c
y_1
Fmin
F
F
III
hump:
IF<1
IF>1
ΔZ
$E_1 = E_2 + \Delta Z$
Q = const
y
y_1
y_2
y_c
y_2
y_1
IF<1
C.D.L
IF>1
Emin
E_2
E_1
E


Drop:
y
Q = const
F < 1
F > 1
y_2
y_1
y_c
E_{min} E_1 E_2 E
ΔZ
$E_1 + \Delta Z = E_2$
IV.
- Q = 20 m³/s
- B. H. S
B = 5.0 m
Req.: - Δy
- B = ? $y_2 = y_c$
- draw
b_2, y_1, y_2
$B_1 = 5$
$B_2 = 3.0$

$2.5 = y_1$ Δy y_2

$B_1 = 5.0\,m$ $B_2 = 3.0\,m$

For B.H.S $\quad B = 2y$

$\therefore \; y = 5/2 = 2.50\,m$

$$\therefore F_1 = \frac{V_1}{\sqrt{g \cdot y_1}} = \frac{20/(5 \times 2.5)}{\sqrt{9.81 \times 2.5}}$$

$= 0.32 < 1$ sub critical

$$\because E_1 = E_2$$

$$y_1 + \frac{Q^2}{2gA_1^2} = y_2 + \frac{Q^2}{2gA_2^2}$$

$$A_1 = 5 \times 2.5 = 12.5\,m^2$$

$A_2 = 5 y_2$

$$2.5 + \frac{(20)^2}{2\times 9.81 \times 12.5^2} = y_2 + \frac{(20)^2}{2\times 9.81 \times (5 y_2)^2}$$

$$2.63 = y_2 + \frac{0.22}{y_2^2}$$

Solve by trial

y_2	2.4	2.45		
R.H.S	2.54	2.58		

$$\Delta y = 2.50 - 2.45$$

$$\simeq 0.05 m \ \#$$

Fc $y_2 = y_c$ $\therefore E_2 = E_{min} = 1.5 y_c$

$$\therefore E_1 = E_2 = 1.5 y_c$$

$$2.63 = 1.5 \times y_c$$

$$y_c = 1.75 \ m$$

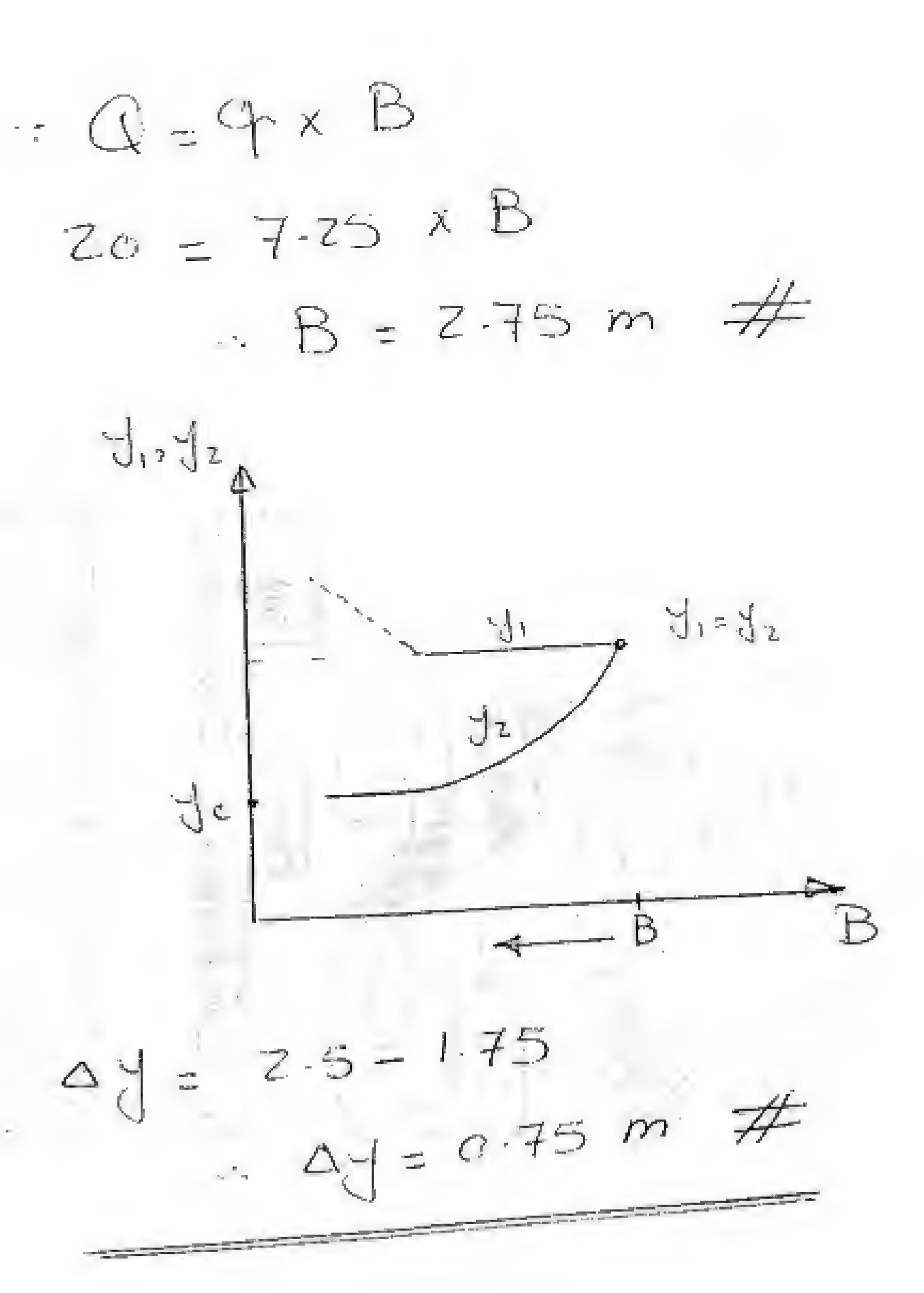
$$y_c = \sqrt[3]{\frac{q^2}{9.81}} \Rightarrow q =$$

$$(1.75)^3 = \frac{q^2}{9.81} \Rightarrow q = 7.25 m^3/s/m$$

$\because Q = q \times B$

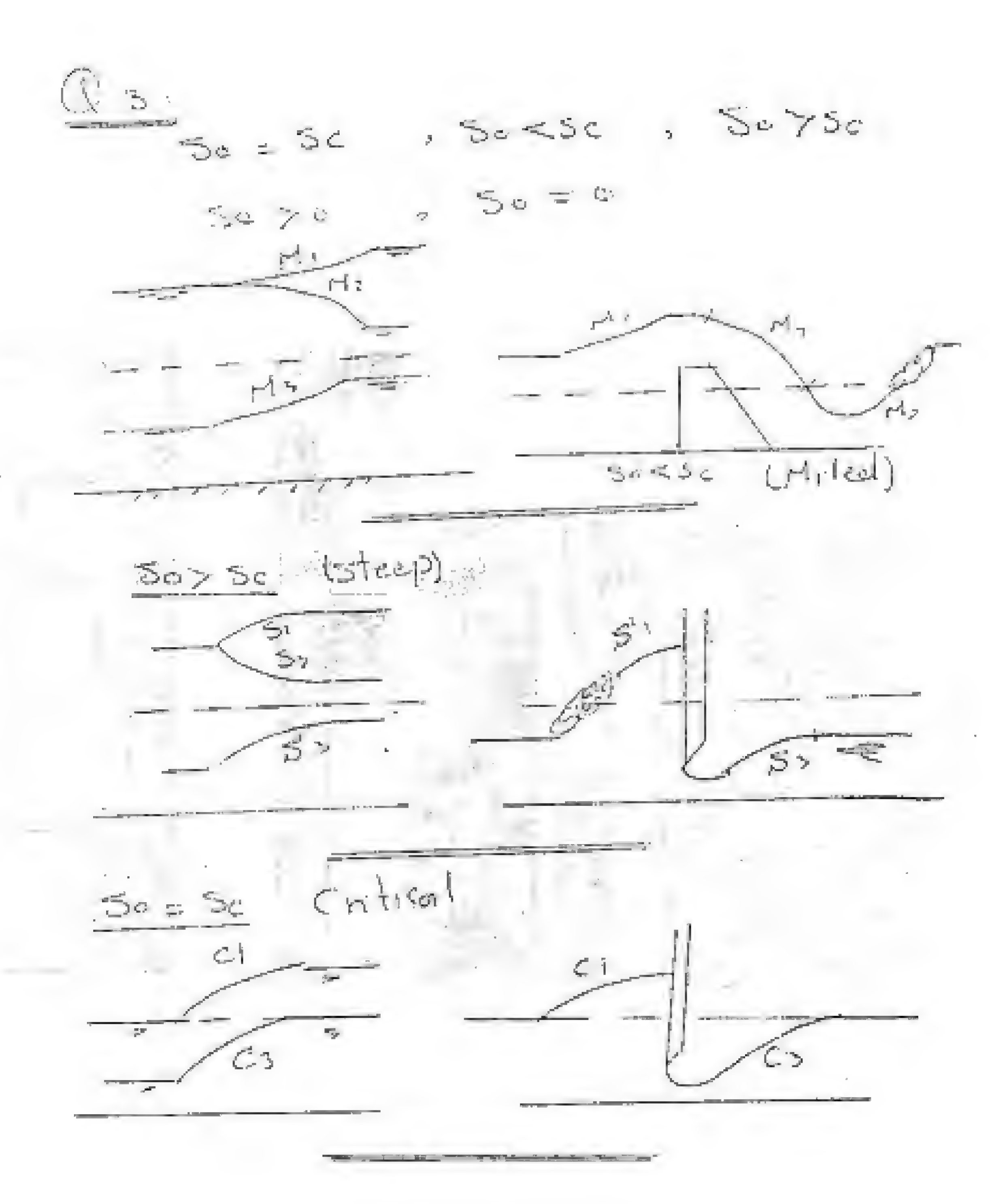
$20 = 7.25 \times B$

$\therefore B = 2.75 \text{ m}$ #



$\Delta y = 2.5 - 1.75$

$\therefore \Delta y = 0.75 \text{ m}$ #


Q 3:
So = Sc , So < Sc , So > Sc
So > 0 , So = 0
M1
M2
M3
So < Sc
(Mild)
So > Sc (steep)
S1
S2
S3
So = Sc Critical
C1
C3

$S_o = 0$ Horizontal

$S_o > 0$ Adverse

III

$-S = 0.002$

$-y = 1.80\,m$

$$\therefore F = \frac{V}{\sqrt{g \cdot y_h}}$$

$$y_h = \frac{A}{T}$$

$$A = (B + Zy)y = (1.5 + 2 \times 1.8) \times 1.8 = 9.18\,m^2$$

$T = B + 2zy$

$= 1.5 + 2 \times 2 \times 1.8 = 8.7$

$\therefore y_h = \frac{9.18}{8.7} = 1.06\ m$

$V = \frac{1}{n} \cdot \frac{A^{2/3}}{P^{2/3}} \cdot S^{1/2}$

$P = B + 2y\sqrt{1+z^2}$

$= 1.5 + 2 \times 1.8 \times \sqrt{1 + 2^2} = 9.55\ m$

$V = \frac{1}{n} \frac{(9.18)^{2/3}}{(9.55)^{2/3}} \times (0.002)^{1/2}$

$= \frac{0.044}{n}$

$F = \frac{0.044}{n\sqrt{9.81 \times 1.06}} = \frac{0.014}{n}$

$n = 0.014$	$F = 1$	Critical
$n < 0.014$	$F > 1$	Super
$n > 0.014$	$F < 1$	sub.

Q(4):

I

$h_L = f(B, b, y_1, y_2, y_3, Q, \rho, \mu, g)$

where $h_L = (y_1 - y_3)$

$h_L = f(B, b, y_2, Q, \rho, \mu, g)$

- No. of variables = 8
- $(L) = f(L, L, L, L^3 T^{-1}, F L^{-4} T^2, F L^{-2} T^{+1}, L T^{-2})$

No. of rebeated = 3.0

- No. of π = 8 - 3 = 5

$\pi_1 = y_2^a \cdot Q^b \cdot \rho^c \cdot h_L$

$\pi_2 = y_2^a \cdot Q^b \cdot \rho^c \cdot B$

$\pi_3 = y_2^a \cdot Q^b \cdot \rho^c \cdot b$

$\pi_4 = y_2^a \cdot Q^b \cdot \rho^c \cdot \mu$

$\pi_5 = y_2^a \cdot Q^b \cdot \rho^c \cdot g$

$$\pi_1 = y_2^{a} \cdot Q^{b} \cdot \rho^{c} \cdot h_L$$

$$F^0 L^0 T^0 = (L)^a \cdot (L^3 T^{-1})^b \cdot (F \cdot L^{-4} T^{2})^c \cdot (L)$$

$F: 0 = c \Rightarrow c = 0$

$T: 0 = -b + 2c \Rightarrow b = 0$

$L: 0 = a + 3b - 4c + 1 \Rightarrow a = -1$

$$\pi_1 = \frac{h_L}{y_2} \quad \#$$

by the same way $\pi_2 = \frac{B}{y_2}$, $\pi_3 = b/y_2$

$$\pi_4 = y_2^{a} \cdot Q^{b} \cdot \rho^{c} \cdot \mu$$

$$F^0 L^0 T^0 = (L)^a \cdot (L^3 T^{-1})^b \cdot (F L^{-4} T^{2})^c \cdot (F L^{-2} T^{+1})$$

$F^0: 0 = c + 1 \Rightarrow c = -1$

$T: 0 = -b + 2c + 1$

$0 = -b - 2 + 1 \Rightarrow b = -1$

$L: 0 = a + 3b - 4c - 2$

$0 = a - 3 + 4 - 2 \Rightarrow a = 1$

$$\pi_4 = \frac{y_2 \cdot \mu}{Q \cdot \rho}$$

$$\pi_5 = y_2^a \cdot Q^b \cdot \rho^c \cdot g$$

$$F^0 L^0 T^0 = (L)^a \cdot (L^3 \cdot T^{-1})^b \cdot (F \cdot L^{-4} \cdot T^2)^c \cdot (L \cdot T^{-2})$$

$F: \; 0 = c \quad \Rightarrow c = 0$

$T: \; 0 = -b + 2c - 2 \quad \Rightarrow b = -2$

$L: \; 0 = a + 3b - 4c + 1$

$0 = a - 6 + 1 \quad \Rightarrow a = 5$

$$\pi_5 = \frac{y_2^5 \cdot g}{Q^2}$$

$$\therefore \frac{h_L}{y_2} = f\left(B/y_2 , b/y_2 , \frac{y_2^5 \cdot g}{Q^2} , \frac{y_2 \cdot \mu}{Q \cdot \rho} \right)$$

$$\frac{y_1 - y_3}{y_2} = f\left(B/y_2 , b/y_2 , \frac{y_2^5 \cdot g}{Q^2} , \frac{y_2 \cdot \mu}{Q \cdot \rho} \right)$$

III.

١- تركيب الهدار

٢- السماح بمرور Q_1

٣- قياس h_1

٤- تكرار الخطوتين ٢، ٣

Q(5) :

(A)

